Unit 5 : Gases and Atmospheric Chemistry

Chapter 9 - The Gas State

- Whether you realize it or not, you encounter many different gases or their products on a daily basis

-Ex. when you open a bag of chips, the "air" you hear escaping is actually nitrogen gas which acts like a preservative to keep the chips intact

-Ex. 2 - a blanket of gases -> the atmosphere surrounds earth

-the atmosphere is around 80 km thick and contains 78% nitrogen, 21% oxygen and other gases

Units for Gases

-So far in chemistry, we have talked mainly about units for liquids and solids

-For gases, another important variable we are going to be looking at is **Pressure**

Gas Pressure: is the result of constantly moving gas molecules striking the inside surface of their container

-SI Unit for pressure = pascal (Pa)
-> 1 Pa = 1 N/m^2

-atmospheric P and pressure of many gases is measured in kPa
-> 1 kPa = 1000 Pa

More Pressure Units

Atmospheric Pressure : P exerted by air on all objects

-average atmospheric P = 101 kPa

-Standard P = 1 standard atmosphere or 101.325 kPa
-> 1 standard atmosphere is given the units atm

-Standard Ambient P = 100 kPa

∴ Standard Conditions :

STP (standard T & P) = 0◦C and 101.325 kPa (or 1 atm)

SATP (standard ambient T & P) = 25◦C and 100 kPa

Other units of Pressure

millimeters of mercury - comes from Hg used in barometers to measure atmospheric P by Torricelli

760 mm Hg = 1 atm = 101.325 kPa

As a short form for this unit we use torr (after Torricelli)

1 torr = 1 mm Hg

Summary of Units

Unit Name	Unit Symbol	Conversion
Pascal	Pa	1 Pa = 1 N/m^2
atmosphere	atm	1 atm = 101.325 kPa
millimeters of mercury	mm Hg	760 mm Hg = 1 atm = 101.325 kPa
torr	torr	1 torr = 1 mm Hg

Ex. Convert standard ambient pressure, 100 kPa, into atmospheres and millimeters of mercury

Variables Affecting Gas Pressure

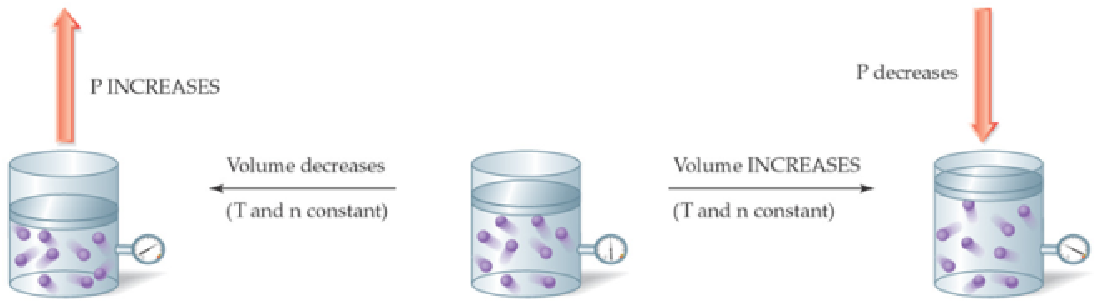
We are going to look at 2 variables that affect Pressure

1)

2)

Boyle's Law : Changing Volume

- Robert Boyle trapped air in a J-tube using liquid mercury.
- He found that the volume of the air decreased as he added more mercury.
- When he halved the volume, the pressure doubled.



Boyle's Law

- Boyle’s law states that the volume of a gas is inversely proportional to the pressure at constant temperature.

- *Inversely proportional* means two variables have a reciprocal relationship.

- Mathematically, we write: $V \propto \frac{1}{P}$

- From this we can make an equation that represents Boyle's law

Equation for Boyle's Law

- Let's take a sample of gas at P_1 and V_1, and change the conditions to P_2 and V_2. If temperature and the amount of gas are constant, we can write:

$$P_1V_1 = P_2V_2$$

Ex. A 1.50 L sample of methane gas exerts a pressure of 2.32 atm. What is the final pressure if the volume changes to 7.00 L?

Temperature Units

-So far we have learned how changes in volume affect the pressure of a gas.

-Next, we are going to see how temperature changes affect the pressure of a gas, but first we have to learn more about temperature

- In chemistry, you have already used the Celsius temperature scale. Now, we are going to learn a different scale :

Kelvin Temperature Scale:

-this T scale is based on the lowest possible temperature we can have **absolute zero**

Absolute zero : on the Kelvin scale absolute zero is -273°C or 0 K

To convert Celsius temperatures into Kelvin temperature all you have to do is add 273.

Ex. Standard ambient temperature is 25°C, convert this temperature into Kelvin.

T = 25°C + 273 = 298 K

Charles' Law

-Before, we look at how changes in temperature affect pressure, we are going to see how changes in temperature affect volume

-Of course, when we do this, pressure and the amount of the gas must be held constant.

Charles' Law :
Volume Vs. Temperature

- Jacques Charles discovered that the volume of a gas is *directly proportional* to the temperature in Kelvin.

- This is ***Charles' law***.

- $V \propto T$ at constant pressure.

- Notice that Charles's law gives a straight line graph.

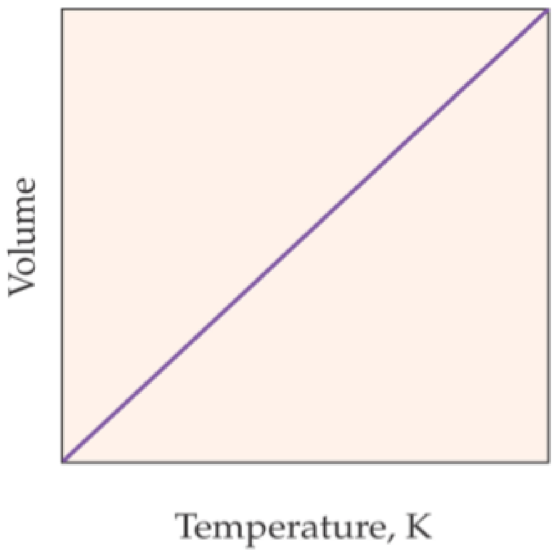


Illustration of Charles' Law

- Below is an illustration of Charles's law.
- As a balloon is cooled from room temperature with liquid nitrogen (–196 °C or ______K), the volume decreases.

Equation for Charles' Law

- Let's take a sample of gas at T_1 and V_1, and change the conditions to T_2 and V_2. If pressure and the amount of gas are constant, we can write:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Ex. A 275 L helium balloon is heated from 20 °C to 40 °C. What is the final volume at constant pressure?